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Request for grant of a patent

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1.	Your reference	PHGB040055GBQ	
2.	Patent application number *(The Patent Office will fill in this part)*	0404996.1	- 5 MAR 2004
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	KONINKLIJKE PHILIPS ELECTRONICS N.V. GROENEWOUDSEWEG 1 5621 BA EINDHOVEN THE NETHERLANDS	
	Patents ADP Number *(if you know it)*	07419294001	
	If the applicant is a corporate body, give the country/state of its incorporation	THE NETHERLANDS	
4.	Title of the invention	ADAPTIVE EYE LENS	
5.	Name of your agent *(if you have one)*		
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	Philips Intellectual Property & Standards Cross Oak Lane Redhill Surrey RH1 5HA	
	Patents ADP number *(if you know it)*	08359655001	
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country / Priority Application number	Date of filing
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application	Date of filing *(day/month/year)*
8.	Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer "Yes" if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	YES	

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9. Enter the number of sheets for any of the following items you are filing with this form.
Do not count copies of the same document.

Continuation sheets of this form	
Description	6
Claims(s)	1
Abstract	0
Drawings	0

10. If you are also filing any of the following, state how many against each item:

Priority Documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (*Patents Form 7/77*)

Request for preliminary examination and search (*Patents Form 9/77*)

Request for substantive examination (*Patents Form 10/77*)

Any other documents (*Please specify*)

11. I/We request the grant of a patent on the basis of this application.

Signature [signature] Date 5/3/04.

12. Name and daytime telephone number of person to contact in the United Kingdom 01293 815143 D. T. MURLEY

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DESCRIPTION

ADAPTIVE EYE LENS

Field of Invention

The present invention relates to the field of variable focus corrective eye lens. The present invention has particular, but not exclusive, application to intra-ocular or implanted eye lens, and to contact lens constructions.

Background to Invention

The paper entitled 'On the possibility of intraocular adaptive optics' by Gleb Vdovin et al. in Optics Express (No.7 2003) describes the possibility to replace malfunctioning human eye lenses by adaptive eye lenses. In particular, the use of liquid crystal based lenses is proposed, since such lenses may consume very little power. Various schemes for powering or actuating the lens are discussed, for example actuation may be achieved by the use of inductive or capacitive power coupling.

However, a problem exists with the use of a liquid crystal based eye lens in that in order to have sufficiently low switching time the liquid crystal layer must be thinner than about 50 microns. This has the unfortunate drawback in the optical power range of such a lens is constricted to about 3 dioptres. Furthermore, liquid crystal lenses may give rise to astigmatism effects when light rays enter the lens obliquely.

Finally, any corrective vari-focus eye lens has material requirements in that any materials used should be biocompatible and not toxic. In the case of a liquid crystal lens this significantly limits the choice of materials available.

Clearly, an adaptive eye lens, which overcomes some or all of the above disadvantages, would be desirable.

Summary of Invention

An adaptive variable focus eye lens, suitable for human implantation or for wearing as a contact lens is proposed. An aspect of the invention lies in the fact that the lens is based on an electrowetting principle. Further aspects of the invention comprise non-contact power coupling modes for powering the lens to control the focus of the lens, and methods of controlling the focus of the lens either automatically or on demand by a user.

In particular, advantages of the proposed lens comprise fast switching times over a large optical power range (100 dioptre switching in around 10ms), and a relaxing in the choice of materials which are biocompatible in comparison with liquid crystal lens.

Detailed description

Figure 1 below illustrates, in a first embodiment a lens suitable for implant.

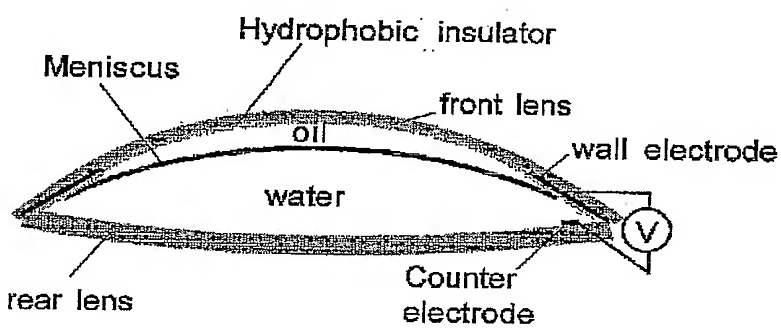

Figure 1.

The lens comprises transparent front and rear lens walls forming a cavity. The cavity is preferably filled with a first liquid such as oil and a second liquid such as water, separated by a meniscus. The walls are provided with

electrodes, preferably in a ring configuration, for applying a potential to the lens. The liquids should be immiscible and of differing refractive indices.

In accordance with the principle of electrowetting, which is well known, application of a voltage between the wall and counter electrode causes the curvature of a meniscus, located between a conductive and non or less conductive solution, to alter. This effectively alters the focus length of the lens assembly, thereby providing an adaptive or variable focus lens.

In this example, preferably the size of the lens may correspond rougly with that of the human eye lens itself. Hence the diameter of the lens may be around 10mm, with the total thickness of the lens being around 4mm.

Suitable bio-compatible materials for the walls and meniscus comprise: PMMA, hydrogel polymers, hydroxyethylmethacrylate, (HEMA) silicone rubbers, cyclic olefin copolymer (COC) and glass. Plastic materials may be coated with inorganic coatings to make them more impermeable for the liquids.

Suitable bio-compatible materials for the liquids comprise, for the second liquid, water or low concentrated salt solution. For example, a particularly good choice corresponds to that of a physiological (body based) salt solution of around 0.9%NaCl in water. Other compatible liquids include glycerol and diethylene glycol. For the first non-conductive liquid a preferred oil is silicone oil.

It is noted that since the non-birefringent materials are proposed, the lens suppresses astigmatic effects since there is little distortion at oblique entrance angles of the rays.

Additionally, the inventors have realised that chromatic aberration of the human eye may be compensated for automatically by controlling the amount of dispersion of the water-like liquid by adding an appropriate amount of salt. Similarly, the dispersion (Abbe) number of the oil may be chosen so that together with the water-like liquid both positive and negative chromatic aberration of the eye lens can be corrected.

An advantageous feature of such a lens as proposed here resides in the fact that it may operate capacitively so that little power is consumed in operation. It is therefore relatively simple to actuate or power the lens

wirelessly through capacitive or inductive coupling techniques. For example, the provision of a coil of transparent indium tin oxide on either the walls or on the circumference of the lens enables simple inductive coupling to change focus length.

Triggering of the change may be accomplished relatively simply by the provision of a power unit and a button on for example an "empty" spectacle frame. Additionally, the inclusion of distance measuring apparatus enables an automatic focusing system to be provided to a user.

Figure 2 below illustrates a "contact lens" embodiment

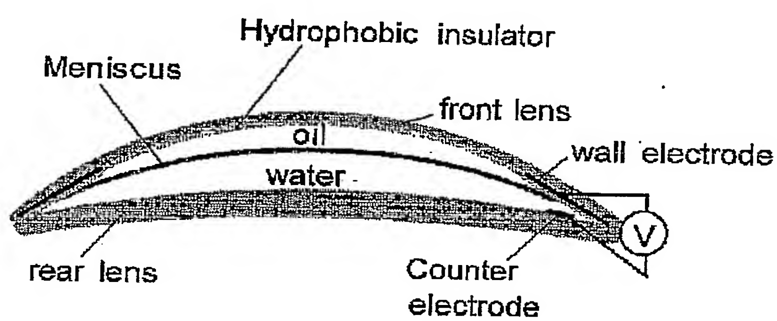

Figure 2

For this embodiment an optically active area of the lens should be of the order of the dimension of the pupil of the human eye which is around 8mm or less. Clearly the choice of materials for the housing (front and rear walls) of such a lens is again similar as before, with hard lenses (plastic housing) and soft lens arrangements being achievable. The curvature of the front and rear walls should be chosen so as to mimic the curvature and size of a patients eyeball.

The outer wall may be permeable to oxygen to aid the "breathing" requirements of the eyeball, whilst in such cases the inner walls of the cavity

should be coated with an impermeable coating to retain the integrity of the lens and to contain the liquids required.

Optionally, it may be possible to use oxygen permeable materials throughout is long-chained molecules are used in the liquids. Hence, the construction of a variable focus, semi permeable contact lens is enabled.

The lens is compatible with wireless operation as described above, and hence is particularly useful to users with both short and long distance eyesight correction requirements. In both embodiments, a sensor may be incorporated to detect rapid blinking of the eye, and this may be used to trigger a focus length change from a focal length suitable for distance vision to one suitable for reading distance.

In the above, construction and operation of an electrowetting based variable focus lens suitable for human implantation, and for wearing as a contact lens is described. The lens may be provided with a large optical power range of operation, may be designed to correct chromatic aberration and exhibits no or little astigmatism effects. Readily available biocompatible materials and liquids are utilised in the construction of the lens. The lens consumes very little power in operation, and may be operated wirelessly to alter focal length in response to a stimulus from a user, or automatically altered in response to a sensor system.

From reading the present disclosure, other modifications will be apparent to persons skilled in the art. Such modifications may involve other features which are already known in the design, manufacture and use of adaptive eye lens and component parts thereof, and which may be used instead of or in addition to features already described herein.

It should be understood that the scope of the disclosure of the present application also includes any novel feature or any novel combination of features disclosed herein either explicitly or implicitly or any generalisation thereof, whether or not it relates to the same invention as presently claimed in any claim and whether or not it mitigates any or all of the same technical problems as does the present invention. The applicants hereby give notice that new claims may be formulated to such features and/or combinations of

features during the prosecution of the present application or of any further application derived therefrom.

CLAIMS

1. An electrowetting based variable focus lens for eye implantation as hereinbefore described and with reference to the accompanying figures.

2. An electrowetting based variable focus contact lens as hereinbefore described and with reference to the accompanying figures.

PCT/IB2005/050699